GRANT / MARSHALL

17p.

SEMIANNUAL PROGRESS REPORT

IN-28688

Grant NAG8-058

INVESTIGATION OF LOW ENERGY SPACE PLASMA

April 1986 - September 1986

by

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Prepared for

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September 1986

(NASA-CR-179745) INVESTIGATION OF LOW ENERGY SPACE PLASMA Semiannual Progress Report, Apr. - Sep. 1986 (Alabama Univ., Huntsville.) 17 p CSCL 20I

N86-33170

Unclas

G3/75 44616

ANALYSIS TECHNIQUES AND SOFTWARE DEVELOPMENT

An interactive version of the technique for temperature and density analysis used in the automated analysis program is under development. This will be similar in operation to the current interactive program, but will use the + or - Z head for temperature analysis and the radial head only for densities. Interactive analysis is desirable for case studies, since it provides the best possible results for a given data set and also provides a clear picture of the quality of the data. This modification will permit us to extend the interactive analysis to other local times and magnetic activity conditions than is presently contained in our analyzed data set.

Flow velocities produced by the flow velocity analysis have been incorporated into the temperature and density analysis in the Automated Analysis Program (for the global empirical model). This is likely to have significant effect only for some portions of the outer plasmasphere and beyond. It will permit the estimate of a better flux density for those regions where the standard RPA analysis cannot be carried out.

We have incorporated a new effect into the parallel equation of motion used in our ion transport calculations. This effect, pointed out recently by Cladis, is essentially a "centrifugal" acceleration on the ion parallel motion given by

$$\underline{V_E} * \underline{db}/dt.$$

This term contributes an important acceleration to the ion motion when the convection velocity is large and the direction of the magnetic field is changing significantly along the ion trajectory, as in the near-Earth tail regions. The resulting energization of O+ can be quite substantial. We have calculated bulk parameters for a number of cases and included this effect in revised plots for two papers in press.

DATA ANALYSIS AND MODELING

A statistical study of 1982 data for occurrences of equatorially trapped plasma has been extended. The previous survey, which utilized only the MSFC summary fiche, has been supplemented with the GSFC summary fiche, which has had the effect of substantially improving the late 1982 coverage. We find that in the post midnight region (1 - 3 LT), the trapped plasma is limited to ± 5 degrees magnetic latitude, while in the early afternoon (13-15 LT), latitude ranges as high as ±30 degrees are found. This survey has provided a link to earlier ATS-6 and ISEE studies of pancake distributions. Although the most energetic, and most anisotopic plasmas are trapped within a few degrees of the equator, the results of these equatorial interactions extend substantially along the magnetic field line in the afternoon and dusk region; and these high latitude extensions were previously studied by the Huntsville group. Results of this study were incorporated into a revision of the equatorial ion paper, which has been resubmitted and accepted (Ref.1).

An investigation of ion and electron heating at high altitudes in the outer plasmasphere has been completed. It was designed to examine the mechanisms for heating the plasma in this region and the possible links between this heating and observed heavy ion enhancements. A parametric study to determine the magnitude of the energy source necessary to raise the ion temperature to observed levels was carried out, and results were reported to the Spring AGU Meeting (Ref. 2). This study showed that to properly account for observations in the ionosphere and at high altitudes, energy must be put into both the electrons and the ions in a ratio of about 10 to 1. The high temperatures which resulted in the model were sufficient to increase the O+ density to values comparable to those observed.

Initial results from a collaborative study with researchers at The University of Michigan indicate that Coulomb interactions involving suprathermal and ring current ions and the thermal plasma can supply the required amount of energy. A detailed case study involving DE 1 and 2 data and modeling is in progress. Data from the EICS instrument on DE-1 has been used to determine the populations of energetic ions within the ring current. Calculations of the amount of energy transferred from these populations to the ambient plasmaspheric ions and electrons via Coulomb interactions give heating rates comparable to those previously predicted by the modeling work. These calculated rates have been used in a new modeling effort and the results (in both ion density as well as ion and electron temperature) are in agreement with measured values. The time necessary to produce the observed O++ and O+ enhancements is consistent with the scenario in which the ring current- plasmasphere

interaction begins near local dusk and continues into the nightside sector. Results from this study will be presented to the Huntsville Workshop on Magnetosphere-Ionosphere Modeling (Ref. 3); and a manuscript is currently in preparation for submission to JGR.

Results of a related collaborative study involving DE-1 and DE-2 observations, together with theoretical calculations, show that the portion of the energy going to the electrons from the Coulomb interactions just noted is sufficient to drive SAR arcs observed simultaneously. They also demonstrate that the spatial distribution of heating is consistent with the distribution of heating needed to produce the observed SAR arcs (Ref. 4,5). Further analysis of the set of coordinated observations has delineated high and low altitude signatures of SAR arc field lines (Ref. 6,7), among them the heavy ion enhancements near the plasmapause, which we have examined in detail with RIMS observations and are preparing for publication (Ref. 8), and which we are studying further with numerical simulations, as noted above.

To improve the number of observations in our statistics, the data base of DE-1/RIMS temperatures and densities has been extended to over 100 plasmasphere transits. Results of the statistical analysis are not qualitatively different from those reported previously. In addition, available ISEE-1/PCE temperatures have been compiled and given a similar statistical treatment. Although the size of the ISEE sample is much smaller than that of RIMS, there is general consistency between the two sets. The quantitative differences of note are a general lower magnitude of dayside

temperatures in the ISEE-1/PCE data set and indications of somewhat more spatial structure. While the lower temperatures in the inner L-shells are consistent with the lower level of solar activity for the time frame of the ISEE observations, the lower temperatures in the outer L-shells require a different explanation, since night side temperatures are higher. A nightside heat source in the outer plasmasphere may resolve this difference. These results were reported to the COSPAR meeting in Toulouse, France (Ref. 9). Additional statistical data on density and composition will be presented to the modeling workshop (Ref. 10).

We have been examining statistical trends in the density profiles in the plasmasphere from the Goddard microfiche. We have obtained a number of interesting statistical results, including the tendency for relatively featureless profiles to occur in the dawn sector and multiple plateau profiles to appear in the dusk-evening side of the plasmasphere. It would appear that these results can be interpreted in terms of the time dependent effects of convection electric fields on the plasmasphere, as discussed, for example, by Chen and Wolf. This work was presented to the COSPAR meeting in Toulouse (Ref. 11).

Theoretical modeling of the neutral upper atmosphere and ionosphere of Uranus has continued. Observations by Voyager showed that the exospheric temperature reached 750 K. Using this temperature and temperatures measured at lower altitudes by the radio science and infared instruments on Voyager new model atmospheres were calculated. The model density profiles for H2 and H are in good agreement with

measured values from the ultraviolet spectrometer. Further work, in collaboration with the UVS team at the University of Arizona, on interpreting the UVS observations and possible mechanisms for the production of the electroglow has been initiated. Calculations for both Uranus and Saturn, in which an additional population of 15-20 eV electrons (from an unspecified source) is added in the region of peak photoelectron production, provide good agreement between the calculated and observed UVS emissions, both in the altitude distribution and overall magnitude. These results suggest that the mechanism responsible for the electroglow is linked to photoelectrons. Results from these studies were presented to the Neil Brice Memorial Symposium on the Magnetospheres of the Outer Planets (Ref. 12).

Analysis of data from the RPA on the Plasma Diagnostics Package (PDP) of STS-3 has begun. The initial effort is focused on determining the ion behavior in the PDP wake.

SPACECRAFT SHEATH STUDIES

An examination of SCATHA ion gun experimental data has been initiated in preparation for the ISTP/TIDE experiment. Preliminary results indicate that the SCATHA experiments involving 20 microamperes current were sufficient to change the satellite potential from +10 V to near zero. Further analysis should make it possible to determine more accurately the current levels necessary to control the satellite potential. In parallel with this study, we re-

examined the experiments with the Aerospace Corporation electrostatic analyzers on SCATHA. These detectors were mounted on booms away from the satellite, and could be biased with respect to the satellite, in the same way the GEOS suprathermal plasma analyzers were. We are re-examining these data to determine the effectiveness of this technique.

Our analysis of electron gun experiments on SCATHA has been extended to include eclipse operations in order to test a hypothesis that there are interactions between the 50-100 eV beam and spacecraft generated photoelectrons. Although there are limited data in the desired modes, the tentative conclusion is that our hypothesis is supported by the recently analyzed data. There are similarities between the eclipse and sunlight data, however, which suggest that in our one good eclipse measurement, there is a naturally occurring cold plasma around the satellite, which is interacting with the beam.

As part of a long term objective of fully understanding the DE-1/RIMS charging behavior, we have performed a statistical correlation of the RIMS density-spacecraft-potential relationship. This first effort uses the plasmasphere data base discussed above, forming a foundation for later work which will extend the analysis to regions beyond the plasmasphere.

LABORATORY PLASMA FLOW STUDIES

Testing of the MASSCOMP software to be used in taking and

displaying data in the two-ion plasma experiment was completed successfully. The MASSCOMP will be used to record the Langmuir probe experimental data. Development of software for analysis has been initiated on the VAX system.

A new signal amplifier was installed in the Differential Ion Flux Probe (DIFP). A 15 Hz low pass filter was added to the DIFP circuit to reduce noise on the signal input to the computer.

MEETINGS

Drs. Chandler and Horwitz and undergraduate B. Giles attended and presented papers at the Spring AGU Meeting. These and other members of the UAH magnetosphere group were authors or co-authors of nine papers (Ref. 2, 4, 6, 13-18) presented there.

Dr. Olsen presented an invited paper (Ref. 19) at the NATO meeting on spacecraft charging in The Hague, Netherlands.

Drs. Comfort, Horwitz and Olsen presented papers to the XXVI COSPAR Meeting in Toulouse, France. Members of the UAH magnetosphere group were authors or co-authors of nine papers (Ref. 7, 9, 11, 20-25) presented to various symposia or topical meetings comprising that Meeting.

Drs. Chandler, Comfort, Horwitz, Olsen and graduate student T. Reyes will participate in the First Huntsville Workshop on Magnetosphere/Ionosphere Plasma Modeling in October. They will be authors or co-authors of six papers presented there (Ref.3, 10, 26-29).

PUBLICATIONS

In addition to the papers noted above, the following papers are at the indicated stage of the publication cycle.

* Papers published during this period are those on: low energy ions around a magnetospheric satellite (Ref. 30), latitudinal plasma distribution in the dusk bulge (Ref. 31), plasma phenomena in wakes (Ref. 32), upwelling ion source characteristics (Ref. 33), plasma and wave observations in a compressional Pc 5 event (Ref. 34), tail lobe ion spectrometer (Ref. 35), velocity filter mechanism for ion bowl distributions (Ref. 36), DE - Chatanika observations of ionosphere / magnetosphere coupling (Ref. 37), ion flows in the plasmasphere (Ref. 38), plasma boundaries in the inner magnetosphere (Ref. 39), transport of accelerated low energy ions in the polar magnetosphere (Ref. 40), ion acceleration during plasma expansion into a vacuum (Ref. 41), and ion energization in upwelling ion events (Ref.42).

* Papers accepted for publication and in press are those on: more Pc 5 plasma and wave observations (Ref. 43), potential modulations of

the SCATHA spacecraft (Ref. 44), DE-1 and DE-2 measurements of plasmasphere-ionosphere coupling (Ref. 45), electric fields near the plasmapause (Ref. 46), ATS-6 record charging events (Ref. 47), solar wind control of the geomagnetic mass spectrometer (Ref. 48), geomagnetic spectrometer in the magnetotail lobes (Ref. 49), and simulation and measurements of ionospheric plasma in the magnetosphere (Ref. 50).

* Papers submitted for publication and in review are those on: O++ in the plasmasphere (Ref. 51), parabolic heavy ion flow (Ref. 52), plasma wake model comparisons (Ref. 53), ring current O+ effects on SARARC formation (Ref. 54), and high altitude electron beam experiments (Ref. 55).

* Papers in draft stage in preparation for submission are those on: semi-empirical modeling of spin modulation of RPA fluxes (Ref. 56), plasmasphere and plasmapause characteristics (Ref. 57), comparisons of theory and data for the tail lobe ion spectrometer (Ref. 21), modeling of electron temperature enhancements in satellite wakes (Ref. 58), and shuttle orbiter plasma wake (Ref. 59).

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